THE LOCAL DIGITAL MESSAGE EXCHANGE: A DESCRIPTION AND ANALYSIS

John David Price

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

THE LOCAL DIGITAL MESSAGE EXCHANGE:
A DESCRIPTION AND ANALYSIS

by

John David Price

Thesis Advisor: J. A. Jolly

March 1973

Approved for public release; distribution unlimited.

The Local Digital Message Exchange:

A Description and Analysis

by

John David Price
Lieutenant, United States Navy
B.S., Indiana University, 1968

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

ABSTRACT

Following a series of incidents in the late 1960's - including the PUEBLO, LIBERTY, and EC 121 - the ineffectiveness of the existing communications system became apparent. The call went out to "get the people out of the system" by automating as many manual functions as possible. The LDMX is one of the first systems designed to correct those problems which has become operational.

Following the introduction, Section II describes the system architecture and the sequence of operating events involved in message processing under this system. Section III presents the requirements which must be met in evaluating such a system and reviews the approach that was taken in meeting them. Two measures of effectiveness are proposed for utilization in evaluating the performance of the LDMX. An additional effort is made to develop several evaluation techniques that could be helpful in developing follow-on systems to the LDMX. Section IV concludes the paper with a brief summary and a discussion of two reports which have had a significant impact on military communications in the past two years.

TABLE OF CONTENTS

I. INTRODUCTION

During recent years greater emphasis has been placed on evaluating proposed Department of Defense investments on a cost-effectiveness basis than on any other single methodology. SECNAVINST 7000.14 [Ref. 13, p. 1] states that such a technique affords significant advantages to the military manager including:

1.) A systematic identification of the costs and benefits associated with resource requirements so that a useful comparison of alternative methods for accomplishing a task can be made;

2.) Highlighting the key variables and the assumptions on which investment decisions are based to allow evaluation of these assumptions;

3.) Evaluating alternative methods of financing the investments (e.g., whether to lease or buy); and

4.) Comparing the relative merits of various alternatives as an aid in selecting the best alternative.

In the actual execution of such studies there has been significant progress in a number of areas, such as weapons system acquisition to give one prominent example. Comparing several rifles on the basis of range, accuracy, reliability and weight and then trading off these effectiveness criteria against the costs involved can yield very meaningful results to a military manager. Similar tradeoffs can be made on items ranging all the way from aircraft to mess kits.

Unfortunately, Naval Communicators have not been able to apply these techniques to their programs as readily as have their counterparts in other fields. Not only has it been very difficult to identify communications assets and to place an accurate price tag on a particular communications system with any degree of confidence; but in addition, it has been impossible to adequately identify the benefits that are realized from a given system or even how these benefits should be measured. Indeed, there are those who persist in claiming that communications are unmeasurable and that no degree of effort will ever permit a full evaluation of communication assets.

With primitive managerial techniques and unenlightened approaches to the problem, which are essentially non-approaches, it is clearly evident why military communications in general and Naval Communications in particular have come under severe criticism in recent years.

The impetus for changing the manner of approaching military programs within the Department of Defense has come about quite naturally as a result of the increasing sophistication, complexity and expense involved in present day systems. This is accompanied by the growing demand from other sectors of the economy for a larger slice of the national fiscal pie. Together the resulting situation is one in which the expenditure of each military dollar must be fully optimized. It is with this larger overall concept in mind that this paper was undertaken.

The objective is to discuss certain modern managerial techniques and to apply them to an ongoing system within the framework of Naval Communications, keeping in mind the context within which we are operating today. Looking at the overall Navy picture, there are currently three areas of interest in the field of communications which provide possibilities for examination: (1) the Fleet Satellite Program; (2) the secure voice problem; and (3) the Naval Communications Automation Program. The first two were ruled out primarily due to the fact that it will be several years before they will be implemented. Only the automation program is actually being implemented at the present time and thus is the only pertinent program that offers a factual enough background upon which to conduct a definite analysis.

Having selected this program, only the Local Digital Message Exchange (LDMX) portion will be reviewed in detail here in order to keep the paper to a manageable level. The objective is to consider all of the aspects of the LDMX in detail and to develop a methodology for evaluating its effectiveness compared to the effectiveness of the manual or semi-automated message centers currently in existence.

The approach is basically three-pronged. First is an analysis of the system as it now exists, including the system objectives and architecture. This is preceded by a review of how the program system initially came into being.

The second phase, Section III, will discuss several considerations which must be taken into account in evaluating a system such as the LDMX. Included will be a description of the current program which is being used to evaluate the LDMX. It will be demonstrated that such an approach does not completely meet all the requirements which must be satisfied in such an analysis. Several proposals for possible methods of providing a more complete analysis are set forth.

The third and final phase presents two important reports - the Mollohan Report and the CIACT Report - which have been published in the past two years. The significant impact these reports have had, and will have, on the application of automated techniques to military communication problems will be pointed out. The final phase concludes with a summary which briefly recaps the primary thrust of the paper.

II. DEVELOPMENT OF THE NAVAL COMMUNICATIONS AUTOMATION PROGRAM[1]

The primary objective of the Naval Communications Automation Program is to obtain a fully automated Naval Communication system which satisfies overall requirements for speed, reliability, security, and systems compatibility.

The shore based portion of this program under development by the Naval Communications Command consists of two interrelated systems: the Local Digital Message Exchange (LDMX) and the Naval Communications Processing and Routing System (NAVCOMPARS). These systems are designed to assist in achieving the objectives of Naval Communications through the application of modern ADP technology and procedures. The approach is to automate key nodal points of the Naval Communications System utilizing the latest devices such as Optical Character Readers, high speed reproduction equipment, Video Display Terminals, remote entry/display devices, and direct on-line computer interfaces, all operating under central processor control.

The afloat portion of the program is being undertaken by the Naval Electronics Laboratory Center (NELC). Because of the complications

---

[1]The information in this section is drawn from Refs. 4, 7, 8, and 10. The interested reader should consult these references for a more complete treatment of this material.

inherent in a shipboard environment, progress in this area has been rather limited. To date, NELC has developed several prototype automated and semi-automated systems, some of which have been installed and operationally tested aboard ship. Overall however, the progress attained afloat in automation has not been as significant as ashore and further analysis of this program is left to future students.

A. BACKGROUND

Within the Navy there are two major problem areas in message processing: (1) the ship-shore interface, and (2) staff internal routing.

Because the staff internal routing problem appeared to lend itself to easier solution, this problem was attacked first, with an RCA 301 being installed in the Pentagon in 1964. It was programmed to assign some seventeen thousand distribution combinations for the Secretary of the Navy and CNO Staff. In 1966, another RCA 301 was installed in Norfolk at the CINCLANTFLT Telecommunications Center. It was larger than the Pentagon system and provided in-staff distribution, file and recall, statistical reporting, and several other functions. In 1967, a third RCA 301 was installed in the CINCPACFLT Telecommunications Center at Pearl Harbor. A fourth and final RCA 301 was installed at Main Navy - now at Crystal Plaza in Washington, D.C. This latter installation was programmed to serve several larger collocated commands. This was the first real attempt at automating and

consolidating smaller and separate telecommunications centers. It should be noted that in each of these installations only the processing of incoming traffic was performed.

Several false starts were made in attacking the ship-shore interface problem and progress was not as rapid as desirable. During the build-up of forces in South East Asia, tremendous traffic backlogs were experienced at Naval Communications Station Philippines. To relieve this situation a large UNIVAC 418 system was installed. The system was expensive and ran into numerous installation problems, however, it did connect on-line to Autodin, served both the fleet center and the on-base message center and allowed enlisted personnel to switch from a two to a four section watch bill.

All in all the initial efforts in automation ashore were rather modest, affected few commands and for the most part were merely one time measures to meet an existing problem. There were two primary reasons for this. First, as with any new development, automation of communications was a complex and difficult task. There were many doubting Thomases -- old line communicators who were not convinced that a computer could be more reliable than a radioman. The other reason was that funds necessary for the development of automation were not forthcoming. Funding slipped from year to year due to other higher priority programs, the lack of any consolidated concerted effort in this direction was the decisive factor.

A series of events in 1967 and 1968 including the LIBERTY, PUEBLO, and EC-121 aircraft incidents gave new impetus to the automation program. I shall not go into these incidents in detail here but the failures in communications (as well as poor judgement) were responsible for situations developing which not only proved embarassing to our government but also resulted in the loss of life.

As a result of these unfortunate incidents both Congress and the Defense Department were spurred to action and the Automation Program took on new life. In 1967, the Chief of Naval Operations promulgated a letter [Ref. 3] establishing the Naval Communications Automation Program and the attendant policy guidance. Specifically, "The program will be based on a systems concept consisting of two primary modularized system components of standardized software and hardware. These components will be:

(1) The Local Digital Message Exchange, (LDMX), a message processor system for interface with Autodin, to meet requirements for distribution of on-base record communications.

(2) The Naval Communications Processing and Routing System, (NAVCOMPARS), a processing and routing system for tactical broadcast, ship-shore, and ship-ship application, afloat and ashore."

B. PROGRAM CONCEPT

The situation was one of steadily worsening conditions accentuated by several very real crises which made it imperative that Naval

communications be automated if the fleet commands and forces afloat were to be responsive to the National Command Authority in the near and far future. The transition between a manual and an automated facility was and is complex and required step-by-step planning prior to implementation. These steps have a significant impact on the cost structure, particularly if significant changes occur in the technology without the anticipated impact being evaluated in terms of the costs involved.

The steps outlined below formed the basis for developing the overall approach to the automation of Naval communications. Based upon the history of both Naval communications technology and ADP technology, these steps were laid out in an orderly progression which allowed for technological changes without complete disruption of planned milestones.

In order to achieve the desired objective of providing Navy users with the fast and accurate communications system necessary to support their communications requirements, it was decided that the program would be installed in three stages.

This evolutionary approach to system design was selected in order to satisfy the communication's requirements of the specific users at each installation, while still contributing to the total system objectives. Hardware and software common to the system, but adapted as necessary for each user, was designed to make this possible. The

three progressive degrees of automation were designated as: (A) Initial; (B) Interim LDMX/NAVCOMPARS; and (C) Full Automation.

Before analyzing these three stages however, I think it is relevant to consider several of the more important reasons why this interim route was chosen in lieu of a total package concept.

First there is the fact that many Naval Commands are not aware of the telecommunications implications of their ADP systems. As a result Naval Communicators are being advised almost daily of new requirements for information exchange. It is prudent to get an interim system installed before sizing up the system specifications for the next stage in the Automation program. This problem of identifying communications and information flow requirements is a separate, serious issue which deserves intensive review as a project of its own.

Additionally there is a problem of reliably terminating HF transmission paths on-line to Autodin. When satellite transmission paths are available for all ships and stations (in about five years) much less trouble is anticipated, but until then messages originated at sea cannot be transmitted on-line to Autodin.

Finally, no vendor has come up with a reliable machine which will produce multiple-page messages, staple them together, and then distribute them to an office or pneumatic tube automatically. The absence of such a device introduces a severe impediment to the attainment of a truly automated message processing system. Until the

development of such a unit is accomplished, a number of error prone, expensive, slow moving humans will remain in the system. No RDT&E funds will be available until FY 74 for this purpose, but nearly 4 million dollars has been set aside for such an endeavor in the period FY 74-76, when this problem will hopefully be resolved [Ref. 4, p. B-7].

1. Initial Phase

Specifications for the LDMX were prepared and submitted for competitive bid during 1969 under Automatic Data Processing Selection Office (ADPESO) Project 004-69 [Ref. 4, p. 7-1]. This specification was written for the lease of an LDMX for the Naval Message Center in the Pentagon and contained options for an additional 13 LDMX systems to be leased over a three year period. Facilities identified by the specification for the optional systems were to be altered to reflect recent planning and operational changes as they occurred. During 1970 and prior to delivery of the Pentagon LDMX, portions of currently available LDMX software were recoded in Cobol to afford some degree of standardization and facilitate user interface. A maximum effort was directed toward the collection and review of new communications requirements which were generated in support of ADP facilities. Consolidations of communications subscribers and transmission facilities was a focal point in planning considerations. Actions also were initiated to update Naval Communications doctrine, policy and procedures as necessary to reflect changes resulting from an automated/data

oriented communications environment. During the Initial Phase, COMNAVCOMM and supporting commands and offices undertook a systematic program of acquainting senior staff members in ADP disciplines and technology, and developed the resources required to coordinate and monitor the day-to-day actions required to carry out this plan.

A test bed facility was established and manned for the purpose of developing, testing, and debugging software for operational systems. This test bed also serves as a means for training operator, programmer, and maintenance personnel. Additionally, simulation scenarios developed for the test bed serve to run sensitivity analysis, testing the LDMX reaction to changing operational environments. The test bed will remain in operation until the end of the program when it will be moved to the final site where it will be installed as an operational unit [Ref. 4, p. 7-1].

2. The Interim LDMX/NAVCOMPARS

The interim phase of automation covers the time period 1971 to 1976 and thus is the one currently under execution. This phase includes the preparation of specifications and procurement of the hardware and software for designated installations and operation on an integrated basis. System capability will be monitored, upgraded, and modified as new equipment, software and additional interface

capabilities are developed and Naval Communications evolves toward the third, a fully automated phase.

During this phase the 13 additional LDMX/NAVCOMPAR's mentioned in the Initial Phase will be implemented on a modular basis. During the final stages of implementation, communications doctrine, procedures and format will have been standardized to the point that terminals can be classified in terms of volume, speed and format (computer, narrative, data, etc.) [Ref. 4, p. 7-2].

3. Full Automation Phase

The third and final phase involves conversion of individually operated installations into a single system. This is to be accomplished by implementing fixed or standard doctrine, procedures and formats throughout the system, conversion of remaining manually oriented computer functions, implementation of software which will allow free exchange and coordination between the LDMX/NAVCOMPARS systems for the purpose of reporting problems, sharing workloads, exchanging routing information, automatic servicing and routing. It will also provide an on-line interface between computers, or man and computers. The LDMX/NAVCOMPARS of Phase III will also allow more efficient utilization of consolidated communications transmission facilities and more rapid exchange of formatted information. A complete description cannot be offered until experience gained during Phases I and II has

been documented and properly analyzed from a systems approach. Phase III is due to commence in 1976 and will be concluded by the early 1980's [Ref. 4, p. 7-3].

C. SYSTEM DESIGN

1. NAVCOMPARS

Up to this point the term LDMX/NAVCOMPARS has been utilized as a single phrase in designating the overall system. While it is true that there are numerous similarities between LDMX and NAVCOMPARS, it is equally as true that they are separate and unique entities designed to perform two separate and distinct functions under very different environments. The LDMX is designed to automate high volume communication activities such as CNO's telecommunications center in the Pentagon while the NAVCOMPARS is designed to automate the functions of the major communications stations. Although the primary thrust of this paper involves an analysis only of the LDMX, a brief discussion of the NAVCOMPARS for the sake of clarity is called for at this point before a detailed discussion of the LDMX can properly take place.

The NAVCOMPARS provides for the unique Naval requirement for interfacing with the operational fleets via multi-channel ship/shore circuits, broadcast and other means. In terms of actual installations only six Naval Communications Stations are scheduled to receive the

NAVCOMPARS, three in the Atlantic -- Norfolk, London, and Naples and three in the Pacific -- Guam, San Diego, and Honolulu. Ships may still terminate with any communication station but their traffic will be processed and entered into Autodin through these six stations.

These six sites are supposedly also going to be the six NAVCOMMSTA's which will serve as the ground terminal access points for the Navy Satellite Program currently under development.

Each NAVCOMPARS installation is a fully redundant system utilizing two separate processors (one on-line, one in a backup mode) and dual access to Autodin. Each NAVCOMPARS has the additional ability to be outfitted with LDMX software modules as required to satisfy local user requirements without impairing the normal NAVCOMPARS functions.

The NAVCOMPARS as set up for NAVCOMMSTA Norfolk, which will receive the prototype system, provides automated message processing for the fleet center as well as the message center and Autodin center. These automated functions include on-line interface to Autodin, the fleet broadcasts, full period ship/shore terminations of land-line quality, dedicated land-line channels, and message center processing and internal routing. The most salient feature is the capability to automatically key the fleet broadcasts on-line from the NAVCOMPARS. This represents a significant milestone in the Naval Communications Automation Program. Other automated functions

[Ref. 10, p. 8] of the prototype NAVCOMPARS include:

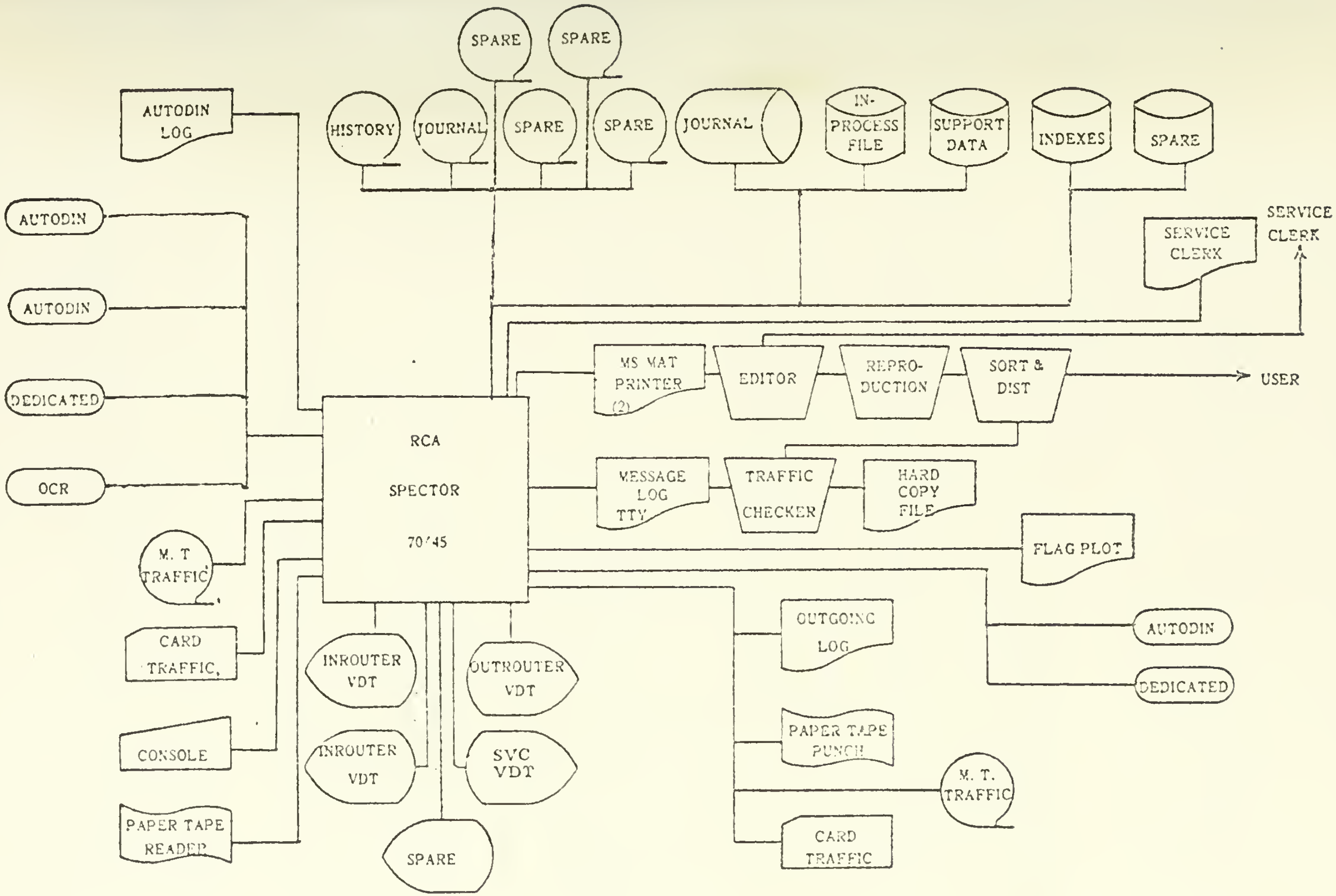
* Format conversion (ACP 126 to ACP 128)
* Message file and recall
* Guard list processing and filing
* Suspected duplicate detection
* Message accountability
* Processing (and queing) by precedence
* Security protection
* Message error format detection
* Statistical reporting

2. LDMX - System Architecture

The LDMX system provides a complete message center capability for high-volume communication activities. It is an on-line system for message input, error checking, storage, and distribution. The interim LDMX system uses leased, commercial, off-the-shelf ADP hardware. The main processor is the UNIVAC Series 70/45 (formerly RCA Spectra 70/45), using the contractor-provided communication operating software system. The software programs for specific communications applications were developed by the Naval Command Systems Support Activity (NAVCOSSACT); they are written partially in Cobol (about 25%) with the remainder in assembly language [Ref. 10, p. 5]. Figure 1 provides the system information flow diagram for the LDMX and forms the basis for the following system description.

a. Incoming

Incoming narrative messages [Ref. 7, p. 13] are received via Autodin and dedicated teletypes terminating in the on-line processor. Messages received by other than electrical means



SYSTEM INFORMATION FLOW

FIGURE 1

(mail, etc.) require manual preparation for entry into the processor. The most desirable input media for these messages would be via Optical Character Reader (OCR). The on-line processor will also accept incoming traffic in the other modes shown including magnetic tape, cards, and paper tape.

After the message has been received it will be stored on disk (In-Process File) written to magnetic tape (History File) for recovery purposes and queued for processing. Messages received by teletype carry an identifying channel sequence number. The system compares the messages received for numbers out of sequence and sets an indicator for out of sequence numbers. The system then generates a notice to the Service Clerk for appropriate action. Messages will be processed from the queue by precedence. Each message will be analysed, removing message control and identifying fields for filing and editing of the message. Based on commands addressed, guard list, Standard Subject Identification Codes (SSIC), flagwords, Address Indicating Groups (AIG) and references, the system will assign internal distribution.

Before continuing, a brief description of the procedure involved in assigning the internal distribution for a Naval message should help clarify this process for those who are unfamiliar with the system. In the commercial world, a piece of correspondence is sent from one organization to another. Normally it will indicate the

individual within the organization for whom it is intended. This is not the case with Naval messages. Nearly all messages are sent only from command to command, rarely, if ever, does a message take on a personal tone where it is from one individual to another. The problem then is obvious, once the message center at a given command receives a message, how does it determine who within the command should see it and who should be responsible for taking whatever action the message calls for. Suffice it to say that although many techniques have been tried, none has ever proven completely successful. There remains a considerable need for system improvement in this phase of message processing.

Once the determination of the correct internal distribution has been made, the complete unedited message with internal distribution assigned will be filed on the mass storage unit (45 day MSU Journal File) and written on magnetic tape (six month magnetic tape Journal File). The disk will contain an index to facilitate random accessing of the messages on the mass storage unit. Under ideal conditions, a message will be processed through the system without operator assistance (about 70% currently in the Pentagon). Messages with processing restrictions or format errors (such as bad Date Time Group (DTG), invalid classification, missing From line, no routing indicator (RI) or command addressed or inaccurate command, AIG or short title) will necessitate the message processing programs be

assisted in the processing of messages by a Video Data Terminal (VDT) operator (INROUTER). In the above instances the Inrouter may correct the format error(s) and then route the message. The Inrouter may also assign distribution, or when necessary, reject messages from the system. In the event of a rejected message (non-correctable format errors or misrouted messages), an unedited copy of the message will be printed at the Service Clerk position with an entry indicating the reason for rejection. After the message has been processed, it will be printed on a reproducible mat in an edited format without communications prosigns and signals but with the internal routing instructions added, and then logged-out of the system by printing summary information on a teleprinter.

The remote printers permit the delivery of selected traffic in an advance copy mode to designated areas. In the Pentagon for instance, the only remote printer is located in CNO's Flag Plot where advance copies of certain messages based on subject code and precedence are made available to the duty officer.

Incoming data communications will be received in data pattern format (80-data-character or variable-line-block messages). Initial processing will be the same as for incoming narrative traffic with the major difference occurring in the output format where either magnetic tape or punched cards may be utilized.

A monitor teleprinter will record all incoming dedicated traffic. In addition to the circuit monitor, the system will maintain a Message and Service Log. The Message Log will receive an entry for all incoming and outgoing messages that are processed by the system. The Service Log will receive entries for each message that is annotated "Service" in the drop line. This log is intended to assist the Service Clerk by making him aware of messages awaiting service action.

b. Outgoing

Outgoing communications [Ref. 7, p. 22] may be introduced into the system via the paper tape reader, card reader, magnetic tape, or preferably through the on-line OCR. The system will accept record communications in either JANAP 128, ACP 127, ACP 126 or Message form DD 173 format for use with the OCR. The system will recognize the format upon entry and validate the start of message and end of message. After validation, the processor will output either an accept or reject notice to the operator via an outgoing log. Together with the action notice, the processor will output a unique header line for identification of the message. Messages which are accepted will be assigned a Processing Sequence Number (PSN) and queued for processing by precedence.

The program first validates the content of the option format lines and elements supplied with the message. If the program

cannot assign a Routing Indicator automatically, it will display the address line to a VDT operator (OUTROUTER). The outrouter may assign the correct RI, place messages on a hold queue, reject the message from further processing, or correct the short title of the addressee. A system status, containing accounting information pertinent to all of the messages on the hold queue, will be displayed to the outrouter, via the VDT, on demand by the operator. The outrouter then may retrieve any message on the hold queue by its queue number. If the message is rejected, it will not be recorded in the system, but a reject notice will be printed on the Outgoing Log.

After all routing has been appended to the message, the preparation program will assign Own Station Routing Indicator, Station Sequence Number and Time of File to the message. It is then paged and sectioned according to JANAP 128 and sent out over the appropriate transmission medium.

Most messages require no review after these automatic processes. However, after preparation of General Messages, Top Secret, and SPECAT messages for transmission, they are automatically presented to the outrouter via his VDT. After reviewing the message and determining that everything is in order he then releases it for automatic transmission.

Data messages may be introduced into the system via magnetic tape or card. During message preparation, processing, transmission, and filing, the same controls and restraints used for narrative traffic will apply.

The system maintains data on-line to assist in message processing. The data base can logically be divided into two segments: the Message Data originated as a result of all messages received for processing (the History and Journal Files discussed previously) and secondly, all Support Data maintained on the remaining disk. This data is organized within the system to permit access by the processing programs. The content of this data is controlled by the Communications Center Personnel and includes:

* The Command Guard List
* Multiple Addressee Guard List
* Long Title File
* Standard Subject Identification Code (SSIC) List
* Flagword List
* Command Distribution Guide Files
* Subject Files

The system provides the capability to retrieve previously processed messages automatically. This is done by entering the message identification parameters via one of the VDT's. Retrieval of Top Secret or Special Category Messages can only be requested via the computer operator's console however.

In the event of failure of the 70/45, a 65K RCA 1600 Autodin Communications Controller (ACC) is configured with extra

memory and additional peripheral switching capabilities that will permit the ACC to continue to receive Autodin traffic on paper tape, card, magnetic tape, and a medium speed printer. This will permit the terminal to function as a multi-media terminal and the output of the printer may be used for the manual processing of Communications Center traffic. The system will generate a magnetic tape log entry of each message incoming, outgoing, or locally entered for logging in the format of the system. The log tapes with all incoming traffic are known as Terminal Tapes and are used in recovering Autodin and dedicated circuit traffic whenever the RCA 70/45 is restarted.

III. EVALUATION

A. THE EFFORT TO DATE

1. Requirements

The guidelines for conducting the required economic analysis for proposed Department of Defense investments are contained in DODINST 7041.3 of 26 February 1969. It delineates the steps to be followed and the format to be utilized in conducting an economic analysis.

The instruction defines an economic analysis as: " A systematic approach to a given problem, designed to assist the manager in solving a problem of choice. The full problem is investigated; objectives and alternatives are searched out and compared in the light of their benefits and costs through the use of an appropriate analytical framework."

SECNAVINST 7000.14 of 30 January 1970 implemented the DOD Instruction and established policy and procedures for consistent application of economic analysis within the Navy.

SECNAVINST 5231.1 of 25 February 1972 provided a standard discipline and framework for managing and justifying Automatic Data System development from inception through to full operation. OPNAVINST 5231.1 of 30 May 1972 implements this instruction and establishes the

evaluation requirements upon which the analysis of systems like the LDMX must be based.

OPNAVINST 5231.1 requires that the ADS Development Plan conform to a highly structured two part format. Part I -- The Economic Analysis Synopsis -- introduces the proposed ADS development, conversion, or major revision. It is a synopsis of the economic analysis presented in Part II. It is designed to permit the system proponent to highlight those key elements which are essential to understanding the analysis; to illuminate critical requirements; to substantiate these requirements in terms of mission objectives; and to validate the particular approach chosen to satisfy them.

Part II -- The Economic Analysis -- presents the analytical justification of the proposed ADS development, conversion, or major revision introduced in Part I. It is separated into nine discrete sections for the expressed purpose of: (1) outlining a step-by-step process for conducting economic analysis of proposals supported by ADS; and (2) amplifying the nature and scope of economic analysis procedures delineated in SECNAVINST 7000.14.

Part II, Section 8 -- Benefits -- is the most relevant segment in the evaluation here. This section states that benefits are to be expressed in terms of measures of effectiveness related to satisfying the objectives of the functional operations supported by the ADS. The principal task to be undertaken in formulating the benefits portion

of the analysis is to isolate the measures of effectiveness in terms of the objectives of the ADS application. There is no unique collection of measures of effectiveness applicable to every analysis. Further, the number of different measures of effectiveness inherent to each analysis is largely a function of the complexity of the ADS under consideration.

2. <u>Approach</u>

The approach taken in complying with the requirements set forth by this instruction is illustrative of one of the major problems in Naval communications today. The problem, which has been touched upon previously, is the inability to measure effectiveness or to determine the benefits (if any) offered by a given communications system. The application of existing analytical evaluation techniques is virtually unheard of.

The project office responsible for implementing the automation program was understaffed and inexperienced in producing such a document so a decision was made to bring in a private consulting firm to perform this task. In the resulting analysis [Ref. 1] , which totalled several hundred pages, only four pages were devoted to the benefits which were to be realized from the LDMX and these were outlined only in very general terms. In fact there were no actual measures of effectiveness developed in the entire analysis. Most of the benefits were couched in phrases such as "anticipated benefits" and "it is

expected." In brief, there was general agreement that the automated system would perform better than the current manual system. No one knew how much better but everyone was sure that it was at least as good. Making this assumption about effectiveness, the justification for proceeding with the LDMX was based on the fact that substantial cost savings would be realized by automating.

It is unfair to fault the consulting firm since they were brought in during the middle of the program. A commitment had already been made to go with the LDMX project so all they could do was to provide the best possible cost analysis. Their basic function was to determine how much money would be saved by automating and to provide an analysis to determine whether it would be more economical to lease or buy the automated system.

The program was too far down the line to run a true cost-effectiveness study on whether or not this was the optimal system for a given level of inputs. It would have been pointless to develop a methodology to determine the optimum system when it was too late to do much about it. The instruction does, however, require that effectiveness be measured and this should be complied with. Ignoring or paying only lip service to the analysis of benefits does not make the problem disappear.

One possible method of meeting this obligation shall be set forth in the following section. The most fundamental approach is

to devise several measures of effectiveness, one for each of the stated objectives, and then to compare these measures as applied to the existing manual system at a given site and to the automated system which is going to replace it. Such a comparison would not provide all the information that is necessary for a complete analysis, but it would be a start.

It may be argued that such an approach will produce inaccurate, incomplete, or biased analytic data. It may also be argued that what is required is an all-encompassing model that analyzes the processing requirements and adjusts the available resources so that an optimal system is attained. It is the author's belief, however, that what is called for here is some simplified way of dealing with the problem of two existing systems, the LDMX and the manual system. The only way to do this is to actually measure the performance of both for a given set of criteria.

An actual evaluation of the two systems will not be conducted here, only the proposed methodology for arriving at some given measure of effectiveness will be explained. An actual application of these proposals will become the responsibility of those who are able to attain freer access to the necessary data than the author.

B. TWO MEASURES OF EFFECTIVENESS

Although separate Measures of Effectiveness (MOE's) could be developed for each of the requirements or stated objectives of the processing systems, in the interest of brevity only two will be presented here. The two that have been selected are illustrative of what can be done with available analytical tools and are offered more as examples than as requirements. They were selected because of their importance to the success of the system. During the three major crises that developed as a result of poor communications during the late 60's -- the LIBERTY, PUEBLO, and EC-121 -- the two most critical problems were: (1) delays in processing and (2) misrouted and non-delivered messages. It is for these reasons that processing speed and reliability of delivery have been selected for analysis.

1. Processing Speed

Delays in message processing in many cases result in a degradation of the content of the message. Prolonged or exaggerated waiting times prior to the servicing of the message normally results in reduced effectiveness. Thus the expected waiting time in a priority network system can be considered to be directly related to the effectiveness of the system and provides an excellent starting point for a discussion of a given communications system.

It should be pointed out that within the Navy it is a function of each message originator to assign a precedence to each message he

sends out. This assignment is a value judgement of the originator based on message content and the time relevance of delivery. The four classes currently utilized with their requirements for processing time are:

(1) FLASH --- less than two minutes;

(2) IMMEDIATE -- less than five minutes;

(3) PRIORITY -- less than 30 minutes; and

(4) ROUTINE -- less than one hour.

None of these objectives is met by the existing manual system but attainment of this level of performance is one of the most important stated objectives of the LDMX [Ref. 4, p. 5-2].

Problems of this type are classified as queing or waiting line problems. This specific type of problem is referred to as a priority system because each message precedence constitutes a separate priority class. Messages arriving with a higher precedence displace all units of lower precedence in the waiting line. Messages of low priority may only be serviced if there are no messages of higher priority waiting to be processed. Within each precedence class, the order of processing is by arrival or first-in first-out.

Since the criterion to be measured here is the time a message of a given precedence spends in the LDMX, if the delay exceeds the prescribed time limits listed above then the performance must be rated at something less than 100%.

Logically the performance index must decrease as the excess time delay increases. The following equation, which was developed in a slightly different form by Lydell [Ref. 6], was selected as being representative of this relationship and thus most appropriate for this purpose:

$$P_p = 1 - e^{-\left(\frac{T_p}{t_p - T_p}\right)} \qquad \text{for } t_p > T_p$$

where:

P_p = performance index for precedence "p" messages,

T_p = maximum desirable time delay for precedence "p" messages,

t_p = actual time delay required for satisfactory processing of precedence "p" messages.

The performance index corresponding to various values of time delay is as follows:

t_p time delay	P_p performance index
$\leq T_p$ minutes	100%
$2T_p$ minutes	63%
$3T_p$ minutes	39%
$5T_p$ minutes	21%

One method of obtaining delay time statistics is to actually measure the delays encountered by each precedence category under various operating conditions. The LDMX currently produces a daily

report from which the following information can be extracted:

1. Number of messages of each precedence per day,
2. Number of messages of each classification per day,
3. Average handling time for each precedence per day,
4. Average handling time for each classification per day,
5. Average handling time for all messages processed for each one hour period throughout the day.

It would appear that a simple modification to the program which produces this daily formatted report could provide the data necessary to implement this simple performance index.

Since there are no ongoing reports which provide this type of information for the current manual system the collection of data for this system would be a more difficult problem to overcome. It is believed, however, that the results of such an effort would be worth the time, effort, and money required.

Care must be taken in all of these measurements since they will consist of an average of all messages over a given period of time (e.g., hour, day, month, etc.). As such, the longer the period of time involved the more the smoothing effect of the averaging process will come into play. The result of this process will be to reduce the impact which those messages that require an excessive amount of time will have on the performance index. For each category, there should be an upper time limit after which any message of a given precedence which exceeds this limit would be reported so that those few messages which experience excessive delays will be recognized.

Another approach to this problem would be to compare two systems only for the average time involved in processing the slowest 25% of all messages of a given precedence over a period of time. This approach assumes that 75% of all messages will be processed in close to the required time and that the point of interest should focus on those messages which experience the most serious delays. By concentrating on this smaller family of messages, a more accurate comparison could be made between alternative systems.

2. Reliability of Delivery

Professor Norman F. Schneidewind has done a significant amount of research in the field of computer software reliability. He points out that a total reliability analysis for a computer system, such as the one involved here, must consider all aspects of the problem including software, hardware, and the human operators involved. A total reliability analysis would address the reliability requirements of each major subsystem, and for each component within a subsystem. Within the hardware subsystem, reliability estimates should be provided for the central processing unit, disks, magnetic tapes, and other peripheral units. Within the software subsystem, reliability estimates should be provided for each module or program [Ref. 11].

Relatively little work has been done in the areas of software and human operator reliabilities, despite the fact that these subsystems are as important as hardware in determining total system

reliability. It is not the intent to conduct an in depth investigation of this problem, but rather to point out that the problem exists and that it merits greater attention. This problem becomes particularly relevant in view of a second stated objective of the LDMX program: "To reduce misroutes and non-deliveries to one in 10 million" [Ref. 4, p. 5-2].

Restating this objective in more manageable terms will help place it in a better perspective. Currently the CNO's Telecommunications Center handles approximately 4,000 messages per day. At this rate the one in 10 million objective means that only one message will be lost or misrouted at that site during the next seven years. A commendable objective even if it is one that stretches the imagination, particularly in view of the difficulties enumerated above.

In order to accurately measure the reliability of delivery for this, or any other communication system, an extensive acknowledgement or hand-shaking type of reporting system would have to be employed. For each message sent out the ultimate receiver would have to send back an acknowledgement notifying the originator of receipt. Such a system is obviously infeasible because of the expense and overloading it would create in the system. It might be possible through an extensive simulation exercise to evaluate the performance of a given system prior to placing it on-line. In this way the probability that misroutes and non-deliveries would or would not occur could be determined for a given system. Anything else seems to be beyond the realm of possibility at the present time.

Existing data on this problem is quite unreliable. Most message centers and communications stations report a very low number of misroutes and non-deliveries on an annual basis. There is general unease about these figures due to the feeling that the reported lost messages represent only the tip of the iceberg so to speak. The only messages ever identified as being lost are those that come to light because someone was expecting a reply and didn't receive one or some required report was not received. In those cases tracer action can be initiated and it can be determined where the message went awry. For the great majority of messages which go out unannounced and for which no reply is required the originator merely hopes that it reaches its final destination. No one can estimate how many of these messages never reach their destination.

It is interesting to note that in those crisis situations which resulted in thorough investigations of the communication failures, a surprisingly high number of lost and misrouted messages turned up. In the LIBERTY crisis alone more messages were lost and misrouted than the Naval Communications Station in San Francisco claimed it lost in all of calendar year 1972. These thoroughly documented failures generate the lack of confidence in the stated reports of delivery reliability.

Until a more adequate method of identifying these lost messages can be devised, any analysis of the data available will be biased in the direction of an over-favorable performance index. The

solution to this dilemma is beyond the scope of this paper and the author's competence. A methodology can be devised based on the data which is available that will compare the reliability of delivery between alternative systems. If one assumes that each suffers the same magnitude of under-statement of the problem, then comparatively speaking the better system in terms of reliability should be recognizable.

The measure developed below is similar in some respects to the measure proposed in the preceding section on processing speed. Basically the reliability index should decrease as the number of identifiable misroutes and non-deliveries increases. The following equation is representative of this relationship:

$$RI = 1 - \frac{N}{K(T)}$$

where:

RI = The reliability index for a given system,

N = The total number of non-deliveries and misroutes over a given period of time,

T = The total messages processed during that period of time

K = A scalar quantity designed to provide a greater spread in the index.

For example, if the CNO Telecommunication Center processes 4,000 messages per day and using a scalar quantity of K = .0001, then the reliability index for the various values of N lost messages for a 30 day period would be:

Number of Non-deliveries	Reliability Index
0	100%
1	92%
2	83%
3	75%
4	67%
5	58%

Other examples using different values for T and K would obviously provide different indexes. The example given above adequately illustrates the procedure however.

C. EVALUATING FUTURE SYSTEMS

The previous discussion has been restricted to an analysis of the increased effectiveness provided by the LDMX when compared to the manual system it is replacing. The more valuable application for the techniques of cost-effectiveness analysis, however, should come in developing a follow-on system to the LDMX. The LDMX should not be viewed as an end in itself, but only as an interim system on the road to a more fully automated system of the future. As such, an inordinate amount of time should not be devoted to the LDMX, but rather the emphasis should be placed on devising a methodology to ensure that, whatever form the follow-on system may take, it will be the optimal one from a cost-effectiveness standpoint. Analysis of previous projects can be helpful in pointing out planning pitfalls to avoid in future efforts and from this standpoint an analysis of the LDMX is beneficial. From a

cost standpoint though, the LDMX project should be viewed as water under the bridge. It is similar to a sunk cost and of value only when viewed from a historical perspective. The only costs of interest to the planner are those that can be controlled, the costs of the future.

A primary shortcoming in development of the LDMX was the approach taken in the initial system design. After the various communications crises in the late 60's, when the order came to get the people out of the system the response was predictable. Following the path of least resistance it was determined that the application of automated data processing equipment to existing procedures would provide an adequate response. There was no significant effort to evaluate the processing stream of events or to streamline management policies and procedures, the message for the most part goes through the same sequence of events as before, it just goes faster and more reliably now because machines are doing the work. This is the same approach taken by industry a decade ago when computers really came into their own in business applications. There was no effort to change the thinking involved, there was only an application of hardware to the old method of doing things.

The first task that must be accomplished in devising a new system should be a review of the entire managerial approach to the problems at hand. How should the mission be defined? What are the goals or objectives to be attained? Are they realistic and relevant to the problem? These are the kinds of basic questions which must be recognized and answered initially.

More specifically, the question of how to accurately evaluate the worth of a message must be resolved. What should a commander be willing to pay to receive a Flash message? What value should be placed on security? How much does it cost to ensure that no messages are misrouted or non-delivered? Is it reasonable to be willing to pay these prices? If processing speed can be increased so that all messages can be received in ten minutes but as a result Flash messages now take eight minutes, is this a reasonable or desirable tradeoff? Little work has been done in this area but these are the kinds of questions that must be addressed before any intelligent decisions can be made in designing communications systems for the future.

1. Time Value of a Message

There have been several recent approaches to the problem of determining the value of a message. One of the most interesting [Ref. 16], was conducted by Professor A. R. Washburn while he was a resident at the Naval Communications Command in Washington. Professor Washburn performed two experiments relevant to the determination of a price of time for Naval messages:

(1) a survey of the opinions of a group of people familair with Naval messages; and

(2) an attempt to discover the price of time that would have had to have been used in order to justify certain past decisions.

A brief summary of this study is included here because of the insight such an approach gives to determining the value of a message.

The quantity of interest throughout the first experiment was the price of time for Naval messages, which was defined to be the amount of money that the Navy ought to be willing to pay to shorten the writer-to-reader time by one hour. Each respondent was required to place a monetary value on the penalty to be assessed for a one hour delay in the arrival of a message for each of the four precedence classes. Each respondent also estimated the maximum penalty to be assessed (in dollars) no matter how long the time delay. This was essentially to determine the penalty for losing a message of a given precedence class.

The Delphi technique, which is a method for obtaining the opinion of a group of people by obtaining repeated personal estimates with feedback in between, was utilized in conducting the actual survey. The survey was repeated three times, in each case showing the participants the results of the previous survey. Estimates tended to get smaller with each survey. The median results of the final survey were \$1, \$10, \$100, and \$1,000 for the four prices of time and \$50, \$500, \$1,000 and \$10,000 for the four maximum penalties. In each case these prices relate to the four message precedences of Routine, Priority, Immediate, and Flash.

The second phase of the study attempted to infer a price of time by examining decisions that have been made in the past involving a tradeoff between time and money. The system which was selected for evaluation was a telecommunications center serving several remote commands. The installation or non-installation of Electronic Courier Service (versus manual pickup) to the remote users was utilized to provide estimates of the price of time, since the required data could be measured or accurately estimated.

The mechanics of the analysis are not of particular importance and have been omitted here. The conclusions, which are important, were difficult to determine. Suffice it to say that the estimates varied considerably, and were in fact, inconsistent with each other in some instances. Of primary importance, though, was the degree that the actual costs varied from those called for by the survey of knowledgeable men conducted earlier. Professor Washburn estimated that based on the results of the second analysis the actual costs involved were more on the order of $.10, $1.00, $10.00, and $200 per hour for the four precedences. The "maximum penalty" numbers were not involved here and could not be estimated.

The actual numbers are not the really important point but rather this type of analysis furnishes one example of what can be done in rethinking the time-honored policies upon which current operations

are based. It is through this form of research that a more realistic attitude to the problems confronting Naval Communications can be attained.

2. Economic Theory

Economic theory is another discipline which should be applied to some of these problems. The marginal theory involved in evaluating the additional effectiveness to be gained by spending an additional dollar should not be overlooked as a possibility in shedding additional light on the situation.

The basis for economic theory involves an analysis of the tradeoffs between various factors. In applying this tradeoff theory to cost-effectiveness studies of systems such as the LDMX, several relationships involving effectiveness come into focus.

Effectiveness (E) is equal to some function of the inputs involved. If, for example, the available inputs (I's) include labor (L), capital (K), managerial expertise (M), and a level of technology (T), then there should be some optimum mix of these input variables which would provide a maximum E.

$$E_1 = f_1 (I_1, I_2, I_3, \ldots\ldots\ldots I_n)$$

where I_1 = Labor

I_2 = Capital

I_3 = Managerial Expertise

.

.

.

.

.

I_n = Etc.

Similarly, a measure of overall effectiveness (E) would also be a function of some subset of "e's" which could be called output measures. The previously discussed reliability and processing speed are examples of these e's. For a given system configuration this subset of e's would define and limit the overall measure of system effectiveness (E).

$$E_2 = f_2 (e_1, e_2, e_3, \ldots\ldots\ldots\ldots e_n)$$

where e_1 = Processing Speed

e_2 = Reliability

e_3 = Security

.

.

.

.

.

e_n = Etc.

Since the E in each case represents the same level of overall performance then the effect of varying the different factors should be readily apparent. If, for example, there are requirements that a given system function at a set performance level for each of the e's, then E will be fixed by these requirements. On the input side, if labor and capital are limited to a given level, as they most surely will be in the foreseeable future, and if technology is assumed to be limited by the state of the art, then M will be the variable in question and such an equation would provide the answer to the question of how much managerial skill would be required to meet this commitment.

On the other side of the coin if all the inputs were fixed at a given level then there would presumably be some optimal level of E attainable under these circumstances. Employing the same logic as before the tradeoffs between the various e's could be evaluated in terms of meeting this overall level of E. Such a model, although very crudely described here, with increased refinement, could provide very valuable insights into optimizing any future system.

In fairness to the designers and developers of the Local Digital Message Exchange, it should be pointed out that they were operating under a very real time constraint. There was a need for a system now and understandably they chose the most expedient alternative in meeting the requirement. The fact that they were able to get the LDMX "on the street" utilizing off-the-shelf equipment that both improved the system and

provided sizeable monetary savings, is a most commendable accomplishment in itself. To undertake the reevaluation proposed above, which involves fundamental changes in communications philosophy, would have required more men, money, and time than was available.

Future systems, however, because of their cost and complexity will no longer be able to rely on this short-range approach. There is an obvious need to bring together users, engineers, systems designers, system analysts, and cost analysts now to begin laying the groundwork for this future system. Without this dual approach of reassessing basic communications philosophy and taking a total systems approach, future system development is assured of being less than optimal.

IV. CONCLUSION

The comments and observations made in the preceding pages have purposely been limited to a single aspect of the overall communication system. The intention has been to focus the discussion on one specific aspect of the system in order to provide the reader with exposure both to the total problem and to possible evaluation considerations which have wider applicability to all Navy communication problems.

A paper such as this cannot be brought to a close however, without recognizing and considering two important reports which have had a significant impact on communications in the past two years. The first report, titled "Review of Department of Defense World-Wide Communications," was conducted by the Armed Services Investigating Subcommittee of the House. Better known as the Mollohan report, after the Congressman who headed the committee, it was published in two stages; Phase I on 10 May 1971 and Phase II on 12 October 1972. Although the Mollohan report did cast a critical eye at Naval communications, it was directed more toward the total military communications effort and the Defense Communications System. The second important report is entitled the "CNO Industry Advisory Committee for Telecommunications (CIACT) Report" and focuses entirely on the current condition of Naval communications. Although the following comments shall be limited to those portions of each report which speak to the problems of automation, the

interested reader can attain a broader perspective through the critical comments these two reports direct at all aspects of military and particularly Naval communications.

A. THE MOLLOHAN REPORT

Phase I of the Mollohan Report reviews in detail the communications failures involved in each of the three major crises in the late 1960's -- the PUEBLO, LIBERTY, and EC-121. The subcommittee's analysis and conclusions are best described with a quote from the report:

> "Our examination of these three situations has caused grave concern over the performance, which could be expected from the Department of Defense Communications, generally, and the Defense Communications System, specifically, in a general war situation. In each of the situations examined by the subcommittee, communications could be carried on under the most favorable circumstances. No facilities had been disabled, either temporarily or permanently; no enemy jamming was experienced; and there was no restriction upon use of any of the various modes of communications available. Despite those almost perfect communications conditions, messages were lost, misrouted and missent, while others experienced intolerable delays for instation processing." [Ref. 14, p. 15].

As noted earlier in this report, the primary objectives of the LDMX program are aimed at rectifying these failures.

Phase II consists of an examination of the tactical communication assets of the military departments and the management practices of DOD and the military departments in procuring, operating, and maintaining those assets. Among their findings in this phase of the report the subcommittee concluded that:

"10. Automated telecommunications center equipment provides faster, more reliable and more responsive communications, and requires fewer personnel for its operation and maintenance. Despite those operational and economic advantages, the military departments have delayed installing such equipment for several years.

11. Excessive message processing time continues to degrade the performance of all Department of Defense communications systems. In 1971, while only 2.2 minutes were required for transmission of the average Flash message, more than 42 minutes were required for processing such a message." [Ref. 15, p. 16490].

In order to improve DOD communications systems the subcommittee recommended that, among other things, the Secretary of Defense should:

"6. Accelerate the program for automating major telecommunications centers. This program should be closely coordinated with the program for interservice consolidation of centers.

7. Initiate a department-wide program to reduce the time consumed in processing messages." [Ref. 15, p. 19491].

These recommendations were amplified and explained in more detail in a separate section of the report entitled "Delay in Automating Communications Centers." Comments in this section included:

> "Automated equipments, which drastically reduced the manual operations in communications centers, have been available for several years. Such equipments provide faster, more reliable communications and permit substantial reductions in the personnel required for operation of the centers. Despite those advantages, only a few military communications centers had been completely automated at the time of our hearings. And, according to the schedules

> of the military departments, it will be about six years before all of the major military communications centers are fully automated.
>
> Since it appears firmly established that automation provides a cost-effective means of obtaining improved and more reliable military communications with reduced operating personnel, the Department of Defense should accelerate its programs for automating major communications centers. Those accelerated automation programs, however, should be coordinated with the Department's program for consolidation of collocated communications centers in order to insure that maximum operational and financial benefits will be obtained from all communication assets." [Ref. 15, p. 16499].

B. THE CIACT REPORT

The importance of the CIACT Report lies in the fact that it concentrates entirely on Navy problems and was conducted at the direct request of the Chief of Naval Operations. Of more direct interest to this paper, it provides, among other things, the most thorough analysis of the role of automation in Naval communications to be found anywhere.

The report consists of ten basic recommendations which must be undertaken to upgrade Naval communications. Each of these recommendations is supported in the basic report with a section of background commentary. In addition to the basic report, each of the ten recommendations has its own Action Group Report which includes the extensive research effort, findings, and recommendations of the team of experts who staffed the recommendation. Recommendation No. 4: Switching

and Communication Automation, staffed by CIACT Action Group Team No. Two, follows:

> "That the Navy Telecommunications System be based on switched, automated communications as the best means to conserve manpower, make more effective use of all available transmission circuits, and improve quality, speed and timeliness of service; specifically: the CNO direct that:
>
> a. Director of Naval Telecommunications (DNT) commit funds and resources immediately to define an automation program for application throughout the system and establish it as a top priority effort.
>
> b. Chief of Naval Material (CHNAVMAT) develop a family of communication switches (ships, submarines, aircraft and shore stations) which provide circuit switching, with store and forward capability, to interconnect all available transmission channels to voice, data, and narrative message subscriber terminals.
>
> c. DNT plan as a fundamental element of each transmission system a capability to measure and control circuit performance automatically for on-line real time knowledge of acceptable circuit routes.
>
> d. DNT implement as a feature of the overall network a method of link-by-link error control and positive acknowledgement of the receipt of information transmitted between network nodes.
>
> e. CHNAVMAT develop a family of low-cost input/output terminal devices for ship and shore application to be used for general message traffic and voice-data applications.

f. CHNAVMAT develop a family of input/output terminal devices for specialized job-oriented functions, such as a message-composer terminal which handles formatted messages when the transmission channel is constrained to low bit rate.

g. CHNAVMAT accelerate the General Address Reading Device (GARD) production from FY 74 to FY 73 and install fleetwide as an initial step in small ship modernization.

h. CHNAVMAT continue the Message Processing and Distribution System (MPDS) program to completion as planned for the CVA-68 and CVA-69 and delay further implementation of MPDS until evaluation of operating experience in these ships is completed.

i. DNT continue the FY 73 plan for installing leased Local Digital Message Exchange (LDMX) and Naval Communications Processing and Routing System (NAVCOMPARS), and add link-by-link control procedures to the NAVCOMPARS.

j. CHNAVMAT accelerate development of an expanded GARD capability (Small Ships Message Processor and Distribution System) for improvement of small ships communication capability.

k. DNT redirect, as dictated by system architecture planning, the current efforts to develop equipments for accessing FLTSATCOM tactical circuits (CUDIXS, SSTIXS, etc.)." [Ref. 2, p. 18].

Further analysis of the CIACT Report will be left to the interested reader. Before leaving though one additional comment which symbolizes the problem, is worthy of note:

"In general the Navy has lagged the other services and the commercial world (by ten years or more) in exploiting the potential of switching systems and communications automation." [Ref. 2, p. 46].

C. SUMMARY

The evidence supporting the need for automation in message processing appears incontrovertible. Pressure from Congress and from within the Navy will undoubtedly result in an increasing reliance on the computer and a further reduction of the human element.

As pointed out previously, the LDMX is not an end product. It is but one component of the overall system. It is however, the first step on the road to the more fully automated systems of the future. For this reason, it is extremely important that the evaluation techniques employed in analyzing the LDMX be appropriate and effective. The employment of the correct techniques now will pave the road for the follow-on systems of the future. The objective of course is to apply the developing technology wisely from the standpoint of the tradeoffs involved between cost and effectiveness.

The increasing sophistication of the hardware, more stringent operating requirements, and the increasing complexity involved in maintaining communications between all of our forces will require an intelligent, analytical approach if optimum systems are to be employed in the future. Anything less cannot and will not be acceptable.

LIST OF REFERENCES

1. Booz-Allen Applied Research, Naval Communications Automation Program ADP Systems Review for Fiscal Year 1973, unpublished report prepared for Commander Naval Communications Command, 30 June 1972.

2. Chief of Naval Operations, CNO Industry Advisory Committee for Telecommunications (CIACT), Final Report, SECRET, 25 July 1972.

3. Chief of Naval Operations Letter OP-94/N2/csh Serial 32200p94, Subject: Policy for the Automation of Manual Communications, 25 November 1967.

4. Commander Naval Communications Command, Naval Communications Automation Program Subsystem Project Plan (SPP), May 1972.

5. DOD Instruction 7041.3, Economic Analysis of Proposed Department of Defense Investments, 26 February 1969.

6. Lydell, Tully J., Telecommunication Resource Performance Analysis and Evaluation, p. 2, unpublished paper prepared for Commander Naval Communications Command, 9 March 1972.

7. Naval Command Systems Support Activity, Automation of CNO Communications Center, Functional Description, NAVCOSSACT Document No. 84C012A FD-01, March 1971.

8. Naval Command Systems Support Activity, Automation of CNO Communications Center, System Specifications, NAVCOSSACT Document No. 84C012A SS-01, 1 August 1971.

9. OPNAV Instruction 5231.1, Automated Data System Development; procedures for the management of, 30 May 1972.

10. Personnel Research Division Bureau of Naval Personnel, Report No. 90-73-2, Personnel and Training Requirements for the Interim (Leased) LDMX/NAVCOMPARS, by M. L. Vecellio, September 1972.

11. Schneidewind, Norman F., An Approach to Software Reliability Prediction and Quality Control, p. 2, Paper No. 350, Naval Postgraduate School, Monterey, California, 1972.

12. SECNAV Instruction 5231.1, Automated Data System Development; procedures for the management of, 25 February 1972.

13. SECNAV Instruction 7000.14, Economic Analysis of Proposed Department of the Navy Investments, 30 January 1970.

14. United States House of Representatives Armed Services Special Subcommittee on Defense Communications, Robert H. Mollohan, Chairman, Review of Department of Defense Worldwide Communications, Phase I, U. S. Government Printing Office, Washington, D. C., 10 May 1971.

15. United States House of Representatives Armed Services Special Subcommittee on Defense Communications, Robert H. Mollohan, Chairman, Review of Department of Defense Worldwide Communications, Phase II, U. S. Government Printing Office, Washington, D. C., 12 October 1972.

16. Washburn, A. R., Price of Time for Naval Messages, Commander Naval Communications Command Memorandum No. 961/ N2NPGS, 21 December 1972.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0212 Naval Postgraduate School Monterey, California 93940	2
3.	Commander, Naval Communications Command Naval Communications Command Headquarters 4401 Massachusetts Avenue Washington, D. C. 20390	1
4.	CAPT W. Hart, Jr., USN Assistant Commander Plans Programs and Requirements Department, N2 Naval Communications Command Headquarters 4401 Massachusetts Avenue Washington, D. C. 20390	1
5.	CAPT R. E. Enright, USN Assistant Commander Communications Systems Planning Department, N7 Naval Communications Command Headquarters 4401 Massachusetts Avenue Washington, D. C. 20390	1
6.	Assoc. Professor J. A. Jolly, Code 55JO Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
7.	Asst. Professor J. P. Hynes, Code 55HJ Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
8.	LT John D. Price, USN 1052 Third Street, Apartment #2 Monterey, California 93940	1

9. Library, Code 55 1
Department of Operations Research and
Administrative Sciences
Naval Postgraduate School
Monterey, California 93940

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIGINATING ACTIVITY *(Corporate author)* Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

REPORT TITLE

The Local Digitial Message Exchange: A Description and Analysis

DESCRIPTIVE NOTES *(Type of report and, inclusive dates)*

Master's Thesis; March 1973

AUTHOR(S) *(First name, middle initial, last name)*

John David Price

REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1973	63	16

CONTRACT OR GRANT NO. PROJECT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Naval Postgraduate School Monterey, California 93940

ABSTRACT

Following a series of incidents in the late 1960's - including the PUEBLO, LIBERTY, and EC 121 - the ineffectiveness of the existing communications system became apparent. The call went out to "get the people out of the system" by automating as many manual functions as possible. The LDMX is one of the first systems designed to correct these problems which has become operational.

Following the introduction, Section II describes the system architecture and the sequence of operating events involved in message processing under this system. Section III presents the requirements which must be met in evaluating such a system and reviews the approach that was taken in meeting them. Two measures of effectiveness are proposed for utilization in evaluating the performance of the LDMX. An additional effort is made to develop several evaluation techniques that could be helpful in developing follow-on systems to the LDMX. Section IV concludes the paper with a brief summary and a discussion of two reports which have had a significant impact on military communications in the past two years.

4.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Automation						
Communications						
Effectiveness						
Measures of Effectiveness						
Message Processing						
Message Switching						

DD FORM 1 NOV 65 1473 (BACK)
S/N 0101-807-6821

Security Classification

A-31409

144055
Thesis
P934 Price
c.1 The local digital
message exchange: a
description and analysis.